Risk assessment mapping of diseases caused by excess heavy metals in river water

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A medico-ecological research method is proposed based on the coupled spatial analysis of zones of excessive pollution of river waters with heavy metals (HM) in the basin of the Nizhnekamskoe Reservoir (catchment area of 186 000 km$^2$) and data on the health status of the local population.

For the spatial analysis of the heavy metal cycle in the river basin (on its surface, in soil, ground and river waters), a physically based ECOMAG-HM model with a daily time step resolution was developed. The model consists of two main blocks: a hydrological submodel of runoff formation and a hydrochemical submodel of migration and transformation of HM in the river basin [1]. The model was calibrated and verified on the basis of long-term hydrometeorological and hydrochemical observations data at 34 hydrochemical monitoring sites. Maps of simulated mean annual HM concentrations in river water were constructed and areas with significant levels of HM contamination (copper, zinc, manganese) were identified, including catchment areas not covered by hydrochemical monitoring.

The population in the study region has notably higher morbidity rate in priority class diseases (of digestive system, urogenital system, blood and hemopoietic organs, as well as disorders related to immunity mechanism) than the average level in Russia. Occurrence of these diseases is mostly determined by the state of the environment and, even more, by the quality of drinking water and consumed biological products (fish). To analyze the influence of the river water contaminated with heavy metals on the health of the population the statistical data on general morbidity in the region had been previously analyzed separately for two age group: adult population and children under 14. The most relevant research object is child morbidity. Children permanently live in the area without being directly exposed to hazardous work conditions and have relatively healthy lifestyle which excludes the influence of additional harmful factors (overeating, smoking, alcohol consumption) that increase the risk of many diseases development.

The coupled spatial analysis of the population morbidity and the river water contamination maps shows that zones with high and excessive population morbidity rates are located mainly within the highlighted areas with increased concentration of HM in the river water. However, it does not seem possible at this point to separate the effects of man-made impact of air, contaminated with toxic emissions, water and locally produced food on the health of the population. Therefore, to obtain more accurate results within the next stage it is planned to conduct spatial statistical analysis of morbidity risk in separate groups of diseases, mostly determined by health effect of...
heavy metal water contamination.


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